DOCUMENT RESUME

ED 248 125 SE 044 775

AUTHOR Vacha, T. H.
TITLE Rockwell AIM 65 Interfacing: Physics Lab Applications, Air Track Kinematics.
PUB DATE 84
NOTE 10p.; Figures 1b and 1c may be marginally legible due to poor print quality.
AVAILABLE FROM T. H. Vacha, 11000 Pleasant Valley Rd., Parma, OH 44130.
PUB TYPE Reports - Descriptive (141) -- Computer Programs (101) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Acceleration (Physics); *College Science; *Computer Oriented Programs; *Computer Software; Higher Education; *Microcomputers; Motion; *Physics; Science Education; *Science Experiments
IDENTIFIERS *Kinematics

ABSTRACT

The Rockwell AIM 65 is recommended for use in physics laboratories. Among advantages cited are that the basic board can be purchased customized; for example, it can be purchased with or without a printer, power supply, extra memory, and other items. In addition, the computer is basically designed to control equipment and take data from peripheral equipment. Programming the AIM 65 for experimental work involves using BASIC and assembly programming languages. Two program listings are included for use in a multiple photocell timing experiment. A flow chart illustrating the specific functions being handled by the assembly program and how computing can be done in either assembly or BASIC is also included. When done by careful students using the computer, the experiment takes 5 minutes. Without the computer, the same experiment takes 2 to 2.5 hours. In addition, without computer control, data collection is slow and cumbersome and errors may range from 7 to 20 percent or higher. Use of the computer for data collection is recommended for advanced students who have had two or three laboratory courses. (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED248125

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
✓ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy

ROCKWELL AIM 65 INTERFACING

Physics Lab Applications
Air Track Kinematics
by T.H.Vacha
Associate Professor of Physics and Math
Cuyahoga Community College

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Terrance H. Vacha
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

This fascinating lecture will center on computers in the laboratory in general as well as the specific case of linear kinematics on the air track.

There were several reasons I gave in early 1983 for purchasing the Rockwell Aim 65 for interfacing instead of other available computers. First, at that time there wqas no computer data collecting system available commercially. Second, any computer based on the 6502 microprocessor would have to be given serious consideration, because this CPU is well documented in the literature. Third, the AIM 65 can be purchased customized. The basic board can be purchased with or without a printer, with or without power supply, with or without extra memory. Well, the list just goes on. Fourth, this computer is basically designed to control equipment and take data from peripheral equipment. Finally, the early 1983 cost of around $800 for printer, editor assembler, multiple data ports, 4K memory, made this computer by far the best deal available.

The transparency demonstrates the placement of the printer, 6502 chip, 6532 time, keyboard, 2332 basic interpreter and assembler, 2332 monitor ROM and text editor, 4k RAM, 6522 VIA and I/O ports.

Programming the AIM 65 for experimental work will involve using the BASIC and ASSEMBLY computer languages.

BASIC programs will be used for:
1. communicating instructions to and from humans;
2. communicating with assembly programs;
3. analyzing data.

ASSEMBLY programs will be used for:
1. turning on and off the I/O ports;
2. sending/receiving information through I/O ports;
3. communicating data to and from BASIC programs;
4. high speed counting and timing;
5. using interrupts.

So, we now have a great physics lab tool. We can measure: VERY SHORT TIMES; VERY LONG TIMES; and we have EQUIPMENT CONTROL. We are no longer confined to experiments longer than our reaction times and shorter than standard lab periods. We can time the length of a single pulse, the time between the rise of two adjacent pulses, etc..

Now, let's look at the flow diagram for the specific program being demonstrated today. Note the specific functions being handled by the assembly program and how computing can be done in either assembly or basic at will.(figure 1)

SE044775

Now, look at the equipment diagrams. We see a very simple DeJong interface to te photocells using a 555 chip. The IR lights are in wired parallel while the phototransistors are in wired series.(figure 2)

Next, note the diagram of connections to the J1 and J3 application strips.(figure 3)

COMPARE, a typical lab period run presently on the air track with future computer equipment.

During a 3 hour lab we now have 2 photocells with timer.

1. We move the photocells
2. Do 3 runs for each of 9 displacements--total 27 runs
3. Yield is nine x vs t pairs
4. Takes 2-2.5 hours for careful students.

Now, the same experiment done with the equipment you now see before you.

1. We do not move the 9 photocells
2. Do 3 TOTAL runs
3. Yield is nine x vs t pairs and v vs t pairs and acceleration values.
4. Takes 5 minutes for careful students.

NOT ONLY IS THE EXPERIMENT COMPLETE WITH DATA--THE COMPUTATIONS ARE ALSO COMPLETE!!

Clearly, the new equipment will change the whole focus of a physics lab project! Now, let us compare a typical lab report with and without computerized data taking equipment.

WITHOUT computer control--data collection is slow and combersome; --data contains much error, 7-20% and higher!; --students analyze data, work with statistical analysis, plot error bars, discuss errors in equipment(which always takes the blame) and discuss errors in technique.

WITH computer timing/control: --volumes of data are generated in very short times; --data can routinely be of very high accuracy(<2%); --total discussion centers on errors in technique.

Finally, should the computers be in the physics lab? Yes and No! NO, for the beginning student who cannot handle volumes of data nor can the beginner efficiently utilize the time "freed up" by a computer nor can he/she understand why systems which should produce high accuracy, may not be. YES, for the advanced student with 2 or 3 lab courses behind them. These students should have experience with modern experimental tools and techniques.

BIBLIOGRAPHY

Circuit and Programming from:

PROGRAMMING AND INTERFACING THE 6502, WITH EXPERIMENTS, by DeJong, Marvin and Howard, Howard W. Sams 1982

Additional help from:

6502 ASSEMBLY LANGUAGE PROGRAMMING, Leventhal, Lance, Osborne-McGraw Hill 1979

THE 555 TIMER APPLICATIONS SOURCEBOOK, WITH EXPERIMENTS. Berlin, Howard. Howard W. Sams 1982

AIM 65 LABORATORY MANUAL AND STUDY GUIDE, Leo Scanlon. John Wiley and Sons, 1981

Fig.1a.

MULTIPLE PHOTOCELL PROGRAM

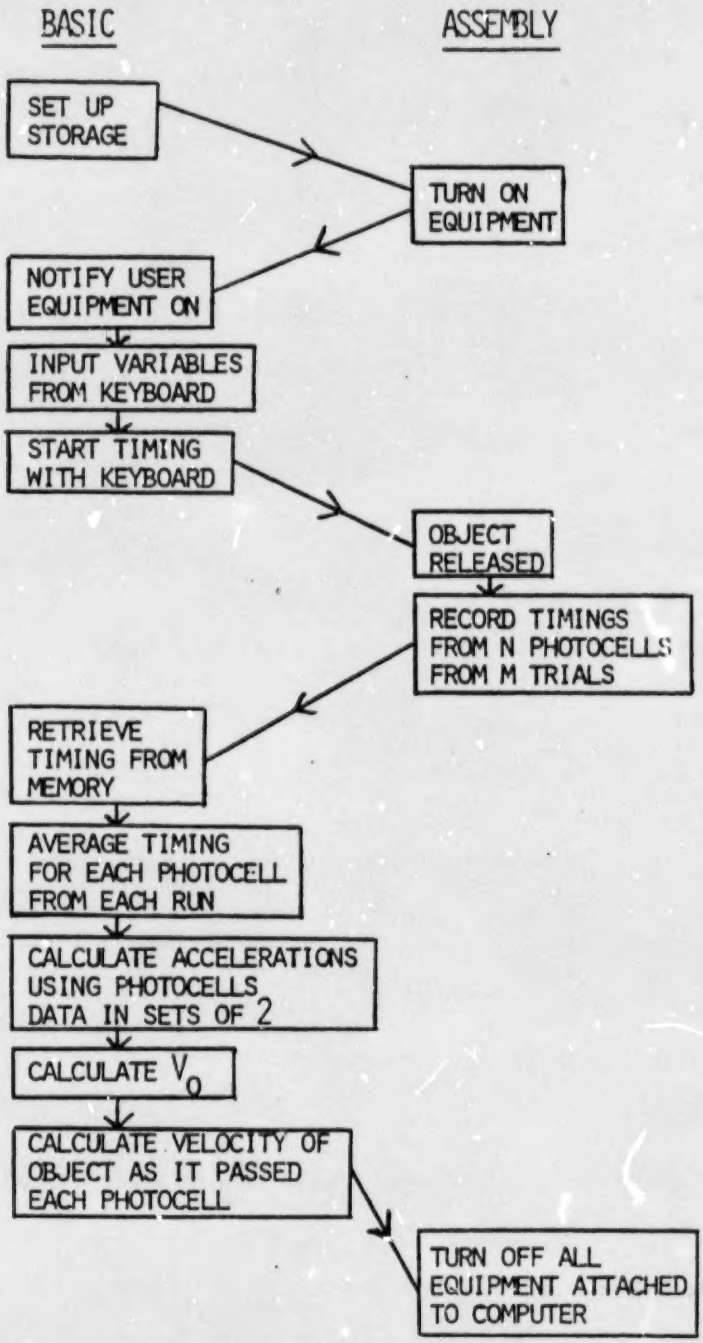

BASIC
ASSEMBLY
SET UP STORAGE
TURN ON EQUIPMENT
NOTIFY USER EQUIPMENT ON
INPUT VARIABLES FROM KEYBOARD
START TIMING WITH KEYBOARD
OBJECT RELEASED
RECORD TIMINGS FROM N PHOTOCELLS FROM M TRIALS
RETRIEVE TIMING FROM MEMORY
AVERAGE TIMING FOR EACH PHOTOCELL FROM EACH RUN
CALCULATE ACCELERATIONS USING PHOTOCELLS DATA IN SETS OF 2
CALCULATE V_0
CALCULATE VELOCITY OF OBJECT AS IT PASSED EACH PHOTOCELL
TURN OFF ALL EQUIPMENT ATTACHED TO COMPUTER

FIG. 16

```
0E10 48 PHA      ┐
0E11 98 TYA      │ SAVE
0E12 48 PHA      │ REGISTERS
0E13 8A TXA      │
0E14 48 PHA      ┘
0E15 A9 LDA #80  ┐
0E17 8D STA A003 │ TURN OFF
0E1A A9 LDA #00  │ PB4,PB5
0E1C 8D STA A001 ┘
0E1F 68 PLA      ┐
0E20 AA TAX      │ RETURN
0E21 68 PLA      │ REGISTERS
0E22 A8 TAY      │
0E23 68 PLA      ┘
0E24 60 RTS
```

```
0F00 48 PHA      ┐
0F01 98 TYA      │ SAVE
0F02 48 PHA      │ REGISTERS
0F03 8A TXA      │
0F04 48 PHA      ┘
0F05 78 SEI  STOP INTERRUPTS
0F06 A2 LDX #00  X=0
0F08 A9 LDA #71  ┐ LOAD ADDRESS OF
0F0A 8D STA A404 │ TIMING INTERRUPT
0F0D A9 LDA #0F  │ ROUTINE
0F0F 8D STA A405 ┘
0F12 18 CLC  CLEAR CARRY FLAG
0F13 A9 LDA #00  ┐
0F15 8D STA 0E01 │ CLEAR THESE
0F18 8D STA 0E02 │ MEMORY
0F1B 8D STA 0E03 │ LOCATIONS
0F1E A9 LDA #C0  ┐ ACR PUT T1 IN FREE-
0F20 8D STA A00B │ RUNNING MODE GENERATING
                 │ INTERRUPTS ON PB7
0F23 8D STA A00E — SETS T1 ENABLE
0F26 A9 LDA #62  ┐ SET T1L-L TO COUNT
0F28 8D STA A006 │ EVERY 100 SEC
0F2B A9 LDA #20  ┐ TURN OFF PB4 LEAVE
0F2D 8D STA A001 │ PB5 ON
0F30 AD LDA A001 ┐ CK PAD FOR +5V & KEEP
0F33 29 AND #01  │ REPEATING IF +5V
0F35 D0 BNE 0F30 ┘ OTHERWISE CONTINUE ON
0F37 AD LDA A001 ┐ CK PAD FOR 0 VOLTS &
0F3A 29 AND #01  │ KEEP REPEATING IF 0 VOLTS
0F3C F0 BEQ 0F37 ┘ OTHERWISE CONTINUE ON
0F3E A9 LDA #00  ┐ TURN CLOCK ON
0F40 8D STA A005 ┘
0F43 58 CLI
0F44 AD LDA A001 ┐ SAME AS 0F30 TO 0F3C
0F47 29 AND #01  │
0F49 D0 BNE 0F44 │
0F4B AD LDA A001 │
0F4E 29 AND #01  │
0F50 F0 BEQ 0F4B ┘
0F52 E8 INX  ADD 1 TO X
0F53 AD LDA 0E01 ┐ PUT TIMER VALUES
0F56 9D STA 0E40,X │ IN SUCCESSIVE MEMORY
0F59 AD LDA 0E02 │ SLOTS FOR EACH
0F5C 9D STA 0E50,X │ PHOTOCELL
0F5F AD LDA 0E03 │
0F62 9D STA 0E60,X ┘
0F65 EC CPX 0E20 — SEE IF ALL PHOTOCELLS HAVE BEEN COUNTED
0F68 D0 BNE 0F11   IF NOT BACK TO 0F2F
```

```
0F6A 78 SEI  — STOP TIMER
0F6B 68 PLA      ┐ RESET
0F6C AA TAX      │ REGISTERS
0F6D 68 PLA      │
0F6E A8 TAY      │
0F6F 68 PLA      ┘
0F70 60 RTS — RETURN TO BASIC
0F71 48 PHA      ┐
0F72 98 TYA      │ SAVE
0F73 48 PHA      │ REGISTERS
0F74 8A TXA      │
0F75 48 PHA      ┘
0F76 A9 LDA #01  ┐
0F78 6D ADC 0E01 │
0F7B 8D STA 0E01 │ COUNT
0F7E A9 LDA #00  │ TIME OUTS
0F80 6D ADC 0E02 │ OF
0F83 8D STA 0E02 │ TIMER
0F86 A9 LDA #00  │
0F88 6D ADC 0E03 │
0F8B 8D STA 0E03 ┘
0F8E AD LDA A004 — RESTART TIMER
0F91 68 PLA      ┐ RETURN
0F92 AA TAX      │ REGISTERS
0F93 68 PLA      │
0F94 A8 TAY      │
0F95 68 PLA      ┘
0F96 40 RTI — RETURN TO ASSEMBLY WHERE LEFT
0F97 48 PHA      ┐
0F98 98 TYA      │ SAVE
0F99 48 PHA      │ REGISTERS
0F9A 8A TXA      │
0F9B 48 PHA      ┘
0F9C A9 LDA #30  ┐ TURN ON
0F9E 8D STA A002 │ PB4,PB5
0FA1 8D STA A00D ┘
0FA4 68 PLA      ┐ RESET
0FA5 AA TAX      │ REGISTERS
0FA6 68 PLA      │
0FA7 A8 TAY      │
0FA8 68 PLA      ┘
0FA9 60 RTS — RETURN TO BASIC
```


TAV

Fig. 1c

```
LIST
 30 DIM X(10),H(10,1
0),S(10,10),T(10),A(
10),V0(10),V2(10)
 70 PRINT"EQUIPMENT
ON":PRINT"RESET APPA
RATUS"
 75 PRINT" "
 80 POKE4,151:POKE5,
15
 85 A=USR(A)
 100 POKE4,0:POKE5,1
5
 130 PRINT"HOW MANY
TRIALS":PRINT"WILL Y
OU DO?"
 131 INPUT M
 150 PRINT"HOW MANY
PHOTOCELLS"
 160 PRINT"DO YOU HA
VE?"
 170 INPUT N:N=N-1
 200 POKE3632,N
 210 FOR I=1 TO N:PR
INT"CM TO CELL";I+1;
 215 INPUT X(I):NEXT
 I
 240 FOR J=1 TO M
 250 PRINT"WHEN READ
Y TYPE":PRINT"R THEN
 ENTER";
 251 INPUT Z$
 252 PRINT"RELEASE O
BJECT"
 295 POKE4,0:POKE5,1
5
 300 A=USR(A)
 350 PRINT"BACK"
 380 PRINT"TIMINGS":
PRINT"CELL      SEC"
 400 FOR I=1 TO N
 500 H(J,I)=PEEK(364
8+I)+256*PEEK(3664+I
)
 510 H(J,I)=H(J,I)+2
56*256*PEEK(3680+I)
 600 H(J,I)=.0001*H(
J,I)
 610 S(J,I)=S(J-1,I)
+H(J,I)
 700 PRINT I+1;" ";H
(J,I)
 800 NEXT I
 805 POKE4,151:POKE5
,15:A=USR(A)
 810 NEXT J
 811 PRINT"AVERAGE T
IMES"
 812 PRINT"CELL
SEC"
 815 FOR I=1 TO N:T(
I)=S(M,I)/M
 817 PRINT I+1;"
";T(I)
 818 NEXT I
 850 FOR I=2 TO N
 855 A(I)=2*(T(I)*X(
I-1)-T(I-1)*X(I))
 856 A(I)=A(I)/(T(I-
1)^2*T(I)-T(I)^2*T(I
-1))
 860 V0(I)=(X(I)-.5*
A(I)*T(I)^2)/T(I)
 864 V2(I)=V0(I)+A(I
)*T(I)
 870 PRINT"A CELL";I
+1;A(I)
 871 PRINT"V0 CELL";
I+1;V0(I)
 872 PRINT"V2 CELL";
I+1;V2(I):PRINT" "
 874 NEXT I
 900 PRINT"EQUIPMENT
 OFF"
 920 POKE4,16:POKE5,
14
 930 A=USR(A)
 1000 END
SAVE
OUT=T F=TIME1 T=1
```

SAVE SPACE FOR ARRAYS

TURN ON PB4, POKE AT 0F97

SET USR(A) FOR 0F00

PUT N AT 0E30

X's ARE DISTANCES BETWEEN CELLS 1&2, 1&3, 1&4, ETC.

DO TIMINGS OF ALL PHOTOCELLS AT 0F00
ALSO TURNS OFF PB4

RETRIEVE STORED TIMINGS

TURN PB4 BACK ON AT 0F97

CALCULATE AVERAGE TIMES TAKEN BY EVERY PHOTOCELL

ACCELERATION USING DATA FROM CELLS 1,2,3 OR 1,3,4 OR 1,4,5 ETC.

INITIAL VELOCITY AT PHOTOCELL 1

FINAL VELOCITY AT PHOTOCELL 2, 3, OR ETC.

TURN OFF ALL EQUIPMENT AT 0E10

FIG. 2

MULTIPLE PHOTOCELL TIMING AIM 65

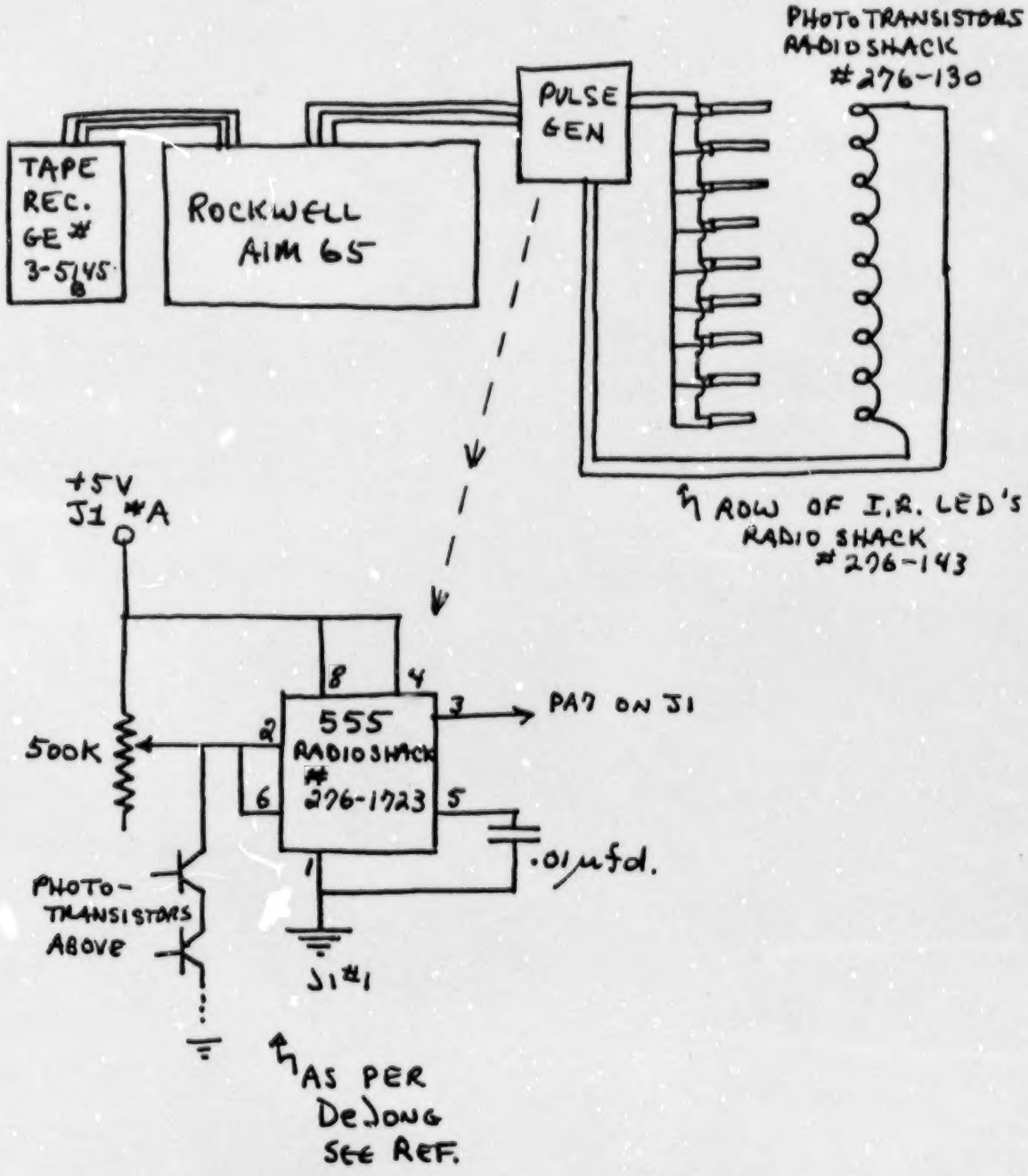
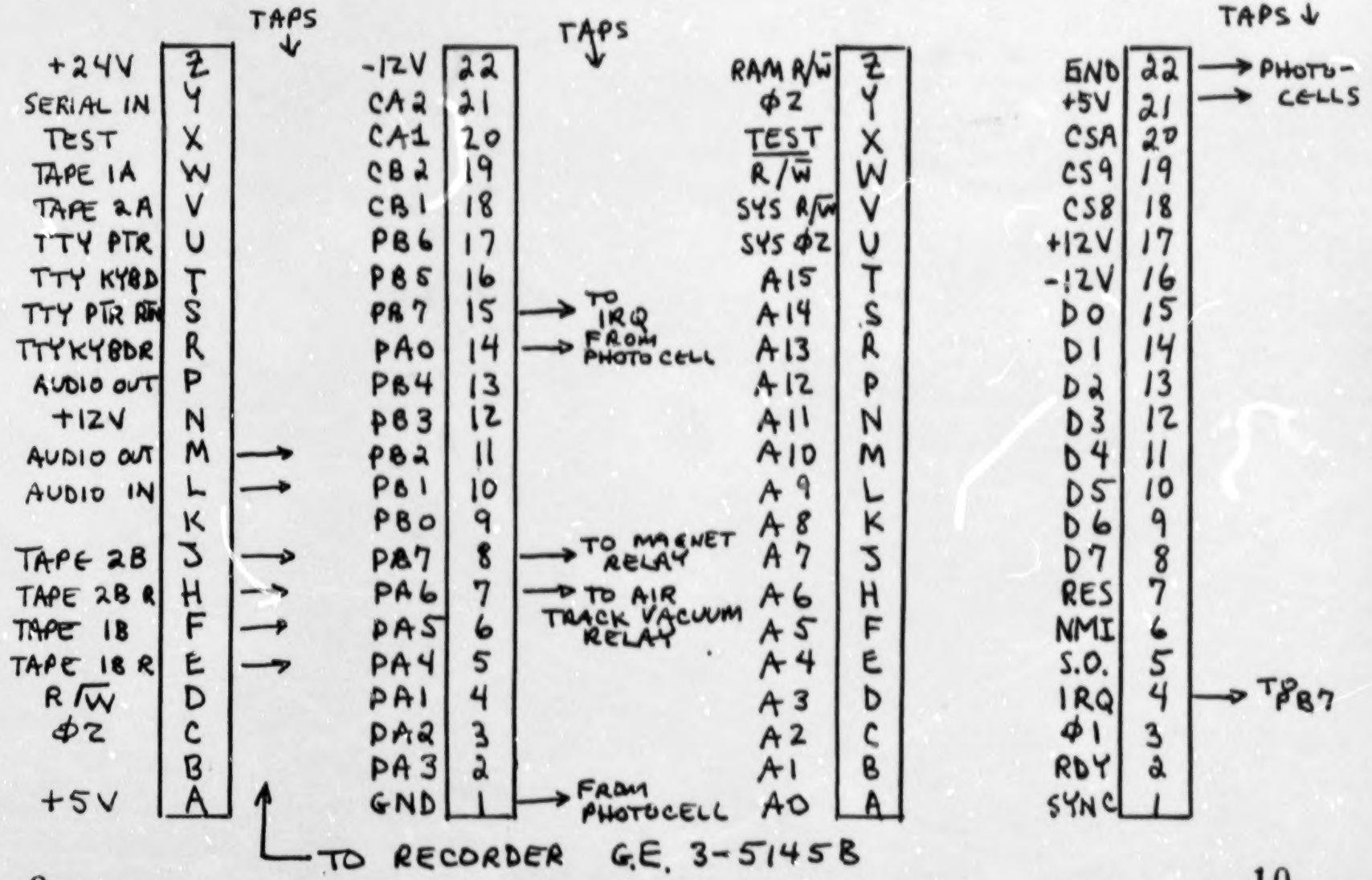


FIG. 3


J1 APPLICATION STRIP
TAPS
+24V Z
SERIAL IN Y
TEST X
TAPE 1A W
TAPE 2A V
TTY PTR U
TTY KYBD T
TTY PTR RTN S
TTY KYBDR R
AUDIO OUT P
+12V N
AUDIO OUT M
AUDIO IN L
K
TAPE 2B J
TAPE 2B R H
TAPE 1B F
TAPE 1B R E
R/W D
Φ2 C
B
+5V A
TAPS
-12V 22
CA2 21
CA1 20
CB2 19
CB1 18
PB6 17
PB5 16
PB7 15
PA0 14
PB4 13
PB3 12
PB2 11
PB1 10
PB0 9
PA7 8
PA6 7
PA5 6
PA4 5
PA1 4
PA2 3
PA3 2
GND 1
TO IRQ
FROM PHOTO CELL
TO MAGNET RELAY
TO AIR TRACK VACUUM RELAY
FROM PHOTOCELL
TO RECORDER G.E. 3-5145B
J2 APPLICATION STRIP
TAPS
RAM R/W Z
Φ2 Y
TEST X
R/W W
SYS R/W V
SYS Φ2 U
A15 T
A14 S
A13 R
A12 P
A11 N
A10 M
A9 L
A8 K
A7 J
A6 H
A5 F
A4 E
A3 D
A2 C
A1 B
A0 A
TAPS
GND 22
+5V 21
CSA 20
CS9 19
CS8 18
+12V 17
-12V 16
D0 15
D1 14
D2 13
D3 12
D4 11
D5 10
D6 9
D7 8
RES 7
NMI 6
S.O. 5
IRQ 4
Φ1 3
RDY 2
SYNC 1
PHOTO-CELLS
TO PB7